FINAL REPORT

LAG-0621-A00-5020-00
Project Number 931-0621

July 1, 1995 through June 30, 2000

Collaborative Interdisciplinary Research and Training Program Using Wheat as a Model to Stimulate Food Production Without Sacrificing the Environmental Sustainability in Developing Countries

Principal Investigator:

Warren Kronstad, Professor
Oregon State University

Cooperating agencies:

CIMMYT, USDA, ICARDA

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Foreward

Dr. Warren Kronstad, internationally renown wheat breeder, geneticist, and Principal Investigator for this contract, died in May, 2000, after a lengthy illness. Throughout his distinguished career, and with support from USAID for over 27 years, Dr. Kronstad had far-reaching impact on wheat improvement and the world's food supply. The following report summarizes the major accomplishments and highlights of the collaborative AID- funded program from 1995-2000. Please recognize that, due to the multifaceted and multidisciplinary nature of this worldwide wheat improvement program, it is not possible to fully assess or document the program's activities and impact, or give proper justice to this Final Report, without Dr. Kronstad's direct contributions.

As a tribute to Dr. Kronstad's vision and means to further document his many contributions that revolved around this USAID project, this report includes the text of his 1996 Keynote Address to the 5th International Wheat Conference and the Proceedings of the Kronstad Symposium, held in his honor on February 19, 1999 (Appendices 1 and 2, respectively).

This report was prepared and submitted by Dr. C. James Peterson, Project Leader and Wheat Breeder, Oregon State University.

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Executive Summary

The collaborative, interdisciplinary, International Winter x Spring Wheat germplasm enhancement and training program was designed to take advantage of the expertise and complementary activities of a major U.S. university, international research centers, and 200 national wheat research programs in the rain-fed and semi-arid areas of developing countries. Genetic biodiversity of wheat was created and enhanced through the systematic hybridization of winter and spring gene pools and improved germplasm was distributed to wheat improvement programs worldwide. This biodiversity contributed to enhanced winter and spring germplasm and varieties for the benefit of both lesser-developed countries (LDC) and U.S. producers. Increased genetic variability was achieved for many traits, including more durable disease resistance and more stable grain yields in stressed environments. A novel and effective "shuttle breeding" strategy involving three countries was developed and utilized to selectively identify new gene combinations with unique and superior characteristics that would contribute to higher yield potential and superior tolerances to biotic and abiotic stresses. Enhanced germplasm, developed and distributed through this collaborative research effort, has contributed to the release of wheat varieties with higher and more stable yields, more durable and multiple source genetic resistances to diseases and insects, enhanced tolerances to abiotic stresses, superior end-product quality, and genotypes which are more compatible with sustainable management practices.

The dissemination of technology was achieved through graduate education and non-degree training, regional and in-country symposiums, exchanges of germplasm and information, and periodic review of national research programs. Emphasis was placed on developing and disseminating technologies that were appropriate and valuable to the primary benefactors, the subsistence farmer in developing countries.

The winter x spring international wheat improvement program served as an effective vehicle for increasing food production in LDCs. It also provided a model that other segments of agriculture can and are following. Involving research, teaching, and extension in an integrated and interdisciplinary manner, it addressed a basic problem found in many LDCs, where agricultural programs are badly fragmented between agencies, universities, and Ministries of Agriculture. The three major segments in this proposal (enhancing germplasm, training young scientists, and serving as a resource center) were designed to help the LDCs help themselves to increase food production on a continuing basis. A significant aspect of this program is that it required scientists and

government decision makers in LDCs to make a visible and accountable contribution to the total international activity of increasing food production on a worldwide basis. In addition, this program has had a clear and recognizable payoff to wheat producers in the U.S. through germplasm exchange and release of improved wheat varieties.

Major Program Objectives

1. Enhance genetic biodiversity of wheat and insure the free exchange of germplasm through the collection, evaluation, development, enhancement, and dissemination of agronomically superior genetic stocks. Exploit the genetic diversity of spring and winter gene pools by systematic hybridization between the pools.

2. Provide meaningful educational experiences for gifted young scientists at the M.S. and Ph.D. levels in plant breeding and genetics and related disciplines. Provide educational and extension training opportunities for mid-career and senior scientists from developing countries.

3. Transfer appropriate technologies by serving as a resource center for germplasm and information involving cereal production, marketing and utilization; provide in-country or regional seminars and workshops; and provide expertise for related USAID missions and national programs.

4. Establish and expand relationships with, and among, organizations in developing countries and wheat research centers located in major wheat-producing areas of the world.

Summary of Accomplishments

1. *International Collaborations*

Highly efficient and complimentary relationships were developed to enhance food production and sustain environmental quality, capitalizing on the expertise and mission of Oregon State University, the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Agricultural Research in the Dryland Areas (ICARDA), and 200 national wheat improvement programs.

2. *International Network for Germplasm Exchange*

An international network for exchanging genetic materials and information regarding winter and facultative wheats involving 45 countries was developed. Countries such as Russia, former states of the Soviet Union, countries in eastern Europe, the People's Republic of China, and many developing countries which were historically highly protective of their plant genetic resources have participated in the program. The effort to collect, enhance, and distribute genetic materials promotes the free exchange of germplasm and has offset the potential negative consequences of international variety protection and plant patenting laws. The programs complements activities of the CIMMYT improvement wheat program with a total of 200 countries involved when both winter and spring wheat cooperators are included.

3. *Systematic hybridization of spring and winter wheat gene pools*

The systematic crossing of winter and spring gene pools of wheat has resulted in significant increases in genetic diversity and contributed to improvement of both spring and winter wheat varieties. Genetic improvements in durable disease resistance, tolerance to environmental stress, high and more stable grain yield, and improved end-use quality were achieved. Important traits that were impacted through combining spring and winter gene pools include 1) improved resistance to stripe, leaf, and stem rusts, foliar diseases such as Septoria leaf blotch, Tan spot, and Powdery mildew, viral diseases such as Barley Yellow Dwarf Virus, and root diseases such as Strawbreaker footrot; 2) improved emergence and stand establishment; 3) higher levels of tolerance to acid and alkaline soils; 4) greater spike fertility; 5) improved end-use quality for products such as bread and Asian noodles; and 6) shorter stature.

4. *Germplasm Accessions and Introgression*

The first step in enhancing biodiversity of wheat involved the acquisition of advanced breeding lines and varieties from an array of national programs, germplasm centers, and private breeding companies. These materials were

evaluated, novel traits and breeding potential characterized, and then the germplasm was hybridized into Winter x Spring populations to incorporate and combine superior genetic attributes. A wide array of valuable genetic stocks were obtained and used in the program, including materials from the Peoples Republic of China, the former Soviet States, Eastern Block countries, Countries in Western Europe, South America, and from programs throughout the US (Table 1).

Accessions with novel genetic traits that were more recently introduced and used in the program include: germplasm with resistance to Head Scab and tolerance to drought and saline soils from the People's Republic of China; lines from Argentina with excellent resistance to *Xanthomonas translusiens* and *Septoria spp*.; dwarfing genes Rht 8, 9, and 10 from Yugoslavian materials; germplasm from Eastern Block countries and new genetic stocks from Australia with tolerance to the Barley Yellow Dwarf Virus; materials from Lithuania representing valuable accessions in danger of being lost from the Vavilov Germplasm Repository in St. Petersburg; and winter durum cultivars with enhanced cold-tolerance from the Ukraine and Hungary.

Approximately 800 to nearly 1,800 single and top crosses were made each year (Table 2). The number of winter x spring F1's received from CIMMYT varied from 300 to 700 each year. Single crosses were made in Oregon among winter types with the objective to both enhance winter parental materials and create combinations for top crossing with the winter x spring F1's received from Mexico. Superior early generation populations and lines were selected using a shuttle breeding strategy by alternating testing of segregating generations among Corvallis, Pendleton, and Moro, Oregon. These three diverse test sites have very different biotic and abiotic stresses and moisture conditions for selection purposes. The superior lines that were identified through the shuttle breeding program were noted for their broad adaptation, resistance to multiple diseases, and tolerance to moisture stress.

5. *International Shuttle Breeding Strategies*

A unique international shuttle breeding strategy was developed and utilized, where superior F3 populations grown at Pendleton were sent to the CIMMYT programs in Ankara, Turkey, and Toluca, Mexico. Figure 1 demonstrates how the winter x spring germplasm was managed through the program. In Turkey, CIMMYT breeders selected within and among the F3 lines for such factors as winterhardiness, rapid grain fill, Zinc deficiency, and Boron toxicity, and local disease complexes. At Toluca, Mexico, lines were selected for day length insensitivity and specific biotic stresses. Following selection, lines were sent out in screening nurseries, including the International Winter x Spring Wheat Screening Nursery (IWSWSN) and the Facultative and Winter Wheat Observation Nursery (FAWWON). This international shuttle successfully

identified lines with very wide adaptation, as well as adaptation to specific production constraints, which contributes to high and stable yields. Lines were developed and identified that possess a broad spectrum of disease resistance, including resistance to leaf, stem, and stripe rusts, foliar diseases such as Septoria, Mildew, and tan spot, Cephalosporium stripe, Common and Dwarf bunt, Barley Yellow Dwarf Virus, and an array of root rotting diseases.

6. *Distribution of Improved Germplasm Through Screening Nurseries*

Improved wheat germplasm derived from domestic and international shuttle breeding efforts was distributed annually in the form of screening nurseries to major wheat research centers throughout the world. The International Winter x Spring Wheat Screening Nursery (IWSWSN) was established in 1973 and, after a short suspension, reinitiated in 1992. The nursery was split into Late and Early Maturing sections, except for the 22nd and final nursery, which was distributed in 1998/99. The nursery was distributed to cooperators in the northern hemisphere in June and those in the southern hemisphere in January to insure seed was in-hand to meet optimal planting dates.

A total of 761 lines were developed and distributed through the IWSWSN program from 1995 to 1998 (Table 3). The nurseries were distributed annually to 103 cooperators in 44 countries. The complete distribution list for cooperating institutions and researchers is included in Appendix 3.

Cooperators of the IWSWSN were accountable to return appropriate data, which were summarized and returned to all participants (see Publication list). In addition to summarizing agronomic data and disease reactions, these reports included information on which lines were selected by cooperators, and for what purpose. The reports assisted breeders in making effective use of the germplasm in their crossing programs and provided an important means for communication and information exchange. The IWSWSN also served as a surveillance nursery, enabling breeders to identify and anticipate changes in physiological races of the major wheat diseases.

7. *Impact on International Variety Development, Release and Production*

The International Winter x Spring program contributed to the development and release of numerous improved varieties that are now having impact on worldwide production. Today over 20 million hectares of production are in wheat varieties developed through this program. In addition, 60 percent of the CIMMYT spring wheat breeding material now includes contributions from winter parents, many of which resulted from OSU efforts. An in-depth review of the impact of these programs can be found in the publication: World Wheat Facts and Trends developed and published by CIMMYT economists.

Major varieties released by national agricultural research centers that were derived directly from OSU or OSU-CIMMYT germplasm are listed in the following table (Table 4a). In addition to these major varieties, currently in production in Turkey, Afghanistan, Tajikistan, and Iran, there are now seven varieties in registration trials for upcoming release in the former Soviet states of Azerbaijan, Georgia, Turkmenistan, and Uzbekistan (Table 4b). These new varieties are expected to make significant contributions to the food supply and food security in the respective countries. This list of varieties is only a partial measure of OSU germplasm contributions to international variety development. There are numerous released varieties and candidate varieties currently in registration trials that have parental contributions from OSU and OSU-CIMMYT developed germplasm. Contributions of OSU-CIMMYT germplasm can be found in the pedigrees of elite lines and early generation breeding stocks of wheat breeding programs throughout the world. Although the program has now closed, the improved germplasm developed and distributed through the International Winter x Spring program will continue to reap benefits and contribute to increased world food production for years to come.

8. *Germplasm evaluation and exchange through the FAWWON program*

OSU distributes the CIMMYT-coordinated Facultative and Winter Wheat Observation Nursery (FAWWON) to wheat improvement programs in the U.S., Canada, and South America (Table 5 and 5b). The FAWWON was initiated and organized by the CIMMYT program in Turkey in the mid-1980's. The nursery includes lines and selections from OSU-developed populations, lines from the CIMMYT-Turkey program, from national programs in western and eastern Europe, states of the former Soviet Union, from U.S. breeding programs, and even varieties from private companies. Through efforts of CIMMYT and OSU, the FAWWON has become a critical vehicle for international germplasm exchange.

Table 5b. Summary of entries distributed through the FAWWON from 1995 through 2000.

Nursery	Year	# of entries
5th	1995-95	210
6th	1996-97	325
7th	1997-98	380
8th	1998-99	165
9th	1999-00	158
10th	2000-01	106

OSU is a critical link in the FAWWON program for U.S. breeders, as OSU has the ability to import germplasm from countries reported to have Flag smut (including Turkey) and provide for quarantine seed increase of the germplasm locally. OSU is unique among U.S. public programs in this regard. Germplasm from both Turkey and Mexico must be grown under special isolated conditions under the plant quarantine permit issued by APHIS to OSU. The concern with material from Mexico is the potential for introduction of Karnal Bunt. This quarantine increase stage and requirement adds significant cost and time to research and seed distribution efforts. However, once the lines are through quarantine seed increase, the seed can be openly distributed to U.S. programs and other countries, such as Canada and those in South America, that have similar restrictions.

9. *Germplasm evaluation and exchange through the WWEERYT program*

The International Winter x Spring Wheat program was expanded in 1997-98 to provide greater focus and support to the newly independent states, Russia, and Eastern Block countries. This was accomplished by establishing a Winter Wheat East European Regional Yield Trial (WWEERYT) in collaboration with CIMMYT (Appendix 6). There are currently 15 countries and 29 cooperators participating in the trial, evaluating 64 elite lines and new varieties each year. The WWEEYRT provides an important mechanism for testing and exchange of elite lines and released varieties that have direct release and commercialization potential in the respective countries. The trial complements the IWSWSN and FAWWON in facilitating germplasm exchange, but with more extensive, replicated yield testing of new varieties and variety candidates. The WWEERYT fills the major voids created by loss of the Nebraska-coordinated International Winter Wheat Performance Nursery in 1989, and loss in 1990 of the COMECON trial, which was an important means for germplasm exchange and variety testing among programs in the Eastern Block countries. To insure maximum benefit of the germplasm exchange and testing, each participant is required to sign the “Wheat Workers Code of Ethics”, which allows for use of material in crossing, but establishes ownership rights of the originating program in any direct commercialization of the germplasm. If a country proposes to commercialize a line from the WWEEYRT, royalties would be collected and shared with the originating breeding program. This is not the case with either the IWSWSN or FAWWON, where the intent is to provide an array of earlier generation materials for evaluation and germplasm exchange. It is hoped that this will help facilitate development of private seed industries within these countries.

In addition to its role in initiating and organizing the WWEEYRT, OSU provides support for annual quarantine increase and distribution of seed to wheat improvement programs in the U.S., Canada, and South America (Table 5). To insure timely distribution of the international nurseries and insure that testing results can be effectively summarized and used by cooperators, the OSU

program grows all candidate lines that are possible entries into the FAWWON, WWEERYT, and WDEERYT. The final distribution list is then selected from among these candidate lines and the nursery is distributed simultaneously by CIMMYT-Turkey and OSU. Rather than simply grow and distribute nursery entries per se, this means that from 875 to over 2000 candidate lines were evaluated and increased under quarantine by the OSU program each year (Table 6).

A meeting of the WWEERYT Coordinating Committee was held prior to the 6th International Wheat Conference in Budapest, Hungary on June 4, 2000. At that meeting, attended by Dr. Peterson and Mary Verhoeven of OSU, the cooperators discussed results and outcomes from the first WEERYT and reviewed technical issues, legal agreements, and participating programs. The cooperators, all of which had invested significant resources and shared germplasm in managing the nursery, were unanimous in their support for the program and expressed appreciation to CIMMYT and OSU for their initiation and coordination of the nursery. Productive discussions were held with regard to opportunities for additional collaborative research among the programs, much of which would revolve around the WWEERYTprogram. All those in attendance considered funding and commitment to the program as a high priority.

10. *Graduate Training*

Through support provided by USAID and funds leveraged through other agencies and national programs, over 100 graduate students have received their M.S. or Ph.D. degrees from this program since its inception. Direct financial support for graduate training by USAID for graduate training was leveraged 10-fold through funds received for training from other agencies or national programs. Many of these former students are now in highly respected leadership positions in their respective countries; in government service, international research centers, or as project leaders of major cereal research and extension programs. This aspect of the International Winter x Spring program is without question the most important and longest lasting contribution made by the project to enhancing world food supplies.

Since 1995, graduate students have completed nine Ph.D. degrees and six M.S. degrees (Table 7). Students were given responsibility for components of the research program and learned through hands-on participation. Through combination of course programs involving modern science and biotechnology, hands-on experience in field plant breeding, team-research approaches, and technology development and application in thesis research, the students obtained fundamental knowledge and work experiences needed to be successful in their respective countries. Thesis research has contributed to the development of new technologies and understanding of key factors which limit wheat production and utilization. Staff from CIMMYT, IRRI, and CIAT have been

involved in student advising, designing thesis research problems, or in providing direct, on-site support for thesis research. These contributions have provided unique student learning opportunities and increased the appreciation of international agriculture in all the OSU students.

A diverse array of genetic problems and production issues were addressed in graduate student research during the last 5 years. The importance of end-use quality in wheat improvement was reflected in several recent research investigations, providing new scientific information on allelic variation in glutenin loci, measures of starch quality in relation to noodle processing, and genetic enhancement and management factors that impact bread quality. A summary of students, thesis titles and abstracts, are included in this report (Appendix 5).

11. *Non-Degree Training and Technology Transfer*

Non-degree training also has been an important component of the program's technology transfer effort. Visiting scientists from 1995 to 2000 are listed in Table 8. Sponsored by USAID and other agencies, these scientists were provided with the opportunity to select genetic material and interact with OSU scientists, extension personnel, and industry leaders in Oregon. In addition to training, these visits have established and maintained important linkages for future research collaborations and germplasm exchange.

In the past five years, USAID funds were leveraged to obtain USDA funding for support of nine scientists from the Baltic countries to spend time with the OSU program. The Project Leader also made several trips to the Baltic countries, resulting in significant germplasm and informational exchanges. In 1997, four scientist from the Ukraine visited Kansas State University, Colorado State University, the National Germplasm Repository, Oregon State University, and CIMMYT, Mexico. In addition, the President of the Academy of Science of Kazakhstan, several Turkish, and a Romanian scientist spent two to four weeks participating in the Winter x Spring program.

On-site scientific exchanges, interactions, and review and assessment of national programs were an important long-term contribution of this OSU-USAID program. A list of site-visits by the Principal Investigator from 1995 through 2000 is included in Table 9. Trip reports and project assessments are included in Appendix 7.

12. *The 5th and 6th International Wheat Conferences*

The USAID-OSU program was a key participant and supporter of the 5th International Wheat Conference held in Ankara, Turkey from June 10 to 14, 1996 (Appendix 7). Over 350 participants attended the Conference, representing every winter and spring wheat growing region of the world. In addition to the

valuable exchange of scientific information, the Conference was a tremendous opportunity to establish new linkages and communications and among wheat researchers and international research programs. Efforts to bring together scientists from the Eastern Block countries, former States of the Soviet Union, and Russia were particularly successful and these contacts will have long-term benefits. The revival of the International Wheat Conference series was greeted enthusiastically by wheat researchers worldwide, filling the critical vacuum created when the Nebraska-USAID sponsored series was discontinued in 1986.

The USAID-OSU program also was a major contributor to the Scientific Organizing Committee for the 6th International Wheat Conference, which was held in Budapest, Hungary, from June 5 through 10, 2000. This highly successful Conference was attended by nearly 400 wheat researchers from around the world, furthering linkages and scientific exchanges that are so critical for improving world food production.

13. *Technology Transfer Activities*

Technology transfer from this program has been accomplished in a number of ways: 1) germplasm exchange, either direct or through the Winter x Spring screening nursery; 2) support of the FAWWON program for international germplasm evaluation and exchange; 3) development and support of the WWEEYRT for evaluation and exchange of elite lines, specifically targeted for Eastern Block countries; 4) in-country or regional seminars where all aspects of cereal production, utilization, and marketing are discussed; 5) travel and interactions with colleagues either at OSU or their respective research centers; 6) sharing of technology with farmers and wheat industry representatives; 7) support for equipment, such as the mixograph provided to Latvian researchers which has had a major impact on evaluation of bread quality in the country; and 8) publication of research in major refereed international journals, conference proceedings, and annual nursery reports.

14. *Winter Durum Improvement Activities*

Winter Durum wheat improvement was initiated as a component of the Winter x Spring program in 1990. Since that time, genetic stocks from CIMMYT, ICARDA, and the countries of Turkey, France, Romania, Hungary, and the Ukraine, and several U.S. programs were introduced for germplasm improvement efforts. The primary goal of the program was to improve pasta quality in winter durum genotypes while concurrently improving yield potential, winterhardiness, and disease resistance. Winter durums from eastern European countries are noted for their lack of protein quality, which is a strength of spring durums from the U.S. In the last 10 years, substantial improvement was made in end-use quality and durum experimental lines were identified with yield potential comparable to common wheat varieties. These improved materials were provided in exchanges

with durum breeders in national programs of Hungary, Turkey, Georgia, and the Ukraine.

With support from OSU, the Winter Durum East European Regional Yield Trial was established by CIMMYT-Turkey in 1998-99. This is the first international nursery dedicated to exchange and improvement of winter durum varieties. Similar to the WWEERYT, the OSU program provided support for the nursery in terms of importation of candidate lines, quarantine increase, harvest, packaging, and distribution of seed to U.S. and South American cooperators. A list of U.S. cooperators receiving seed of the 2nd WDEERYT in September, 2000, is included (Table 10).

Closeout Activities

This was the final contract in 27 years of consecutive funding by USAID for the OSU international wheat improvement effort. As such, many activities and expenditures during the final two years were allocated to facilitate closeout of the contract and downsizing of the OSU wheat improvement program.

1. The first priority during closeout was to insure that the large wheat germplasm base developed at OSU was properly maintained for future use by international breeding programs. From 1997 to 1999, over 5,000 lines and populations were provided to CIMMYT programs in Turkey and Mexico (Table 11). These included many F1's and early generation segregating populations in addition to advanced lines. The advanced lines also were entered into the CIMMYT Germplasm Collection to insure long-term maintenance and availability. The most valuable of the OSU genetic stocks also were provided to the USDA National Plant Germplasm Collection at Aberdeen, Idaho for long-term maintenance, storage, and distribution (Appendix 8). Numerous sets of lines and populations also were provided directly to national research programs and long-time cooperators during this time, at their request, in addition to the distribution of genetic stocks in the final IWSWSN (Table 12). OSU has a large in-house germplasm collection that includes thousands of genetic stocks provided to OSU by colleagues and nursery cooperators. These stocks have been placed in cold storage and are being monitored for viability.

4. During the closeout phase of the contract, OSU has remained committed to quarantine increase and distribution of the FAWWON, WWEEYRT, and WDEEYRT. Candidate stocks for these international nurseries were planted in fall, 1999. The stocks were harvested in August, 2000 and distributed to cooperators in August and September. As wheat growth cycles do not necessarily coincide with fiscal years, OSU committed internal funds to cover costs after June 30, 2000, the closing date of this contract, which included all harvest, seed processing, packaging, and mailing costs. This was committed by

OSU to insure that U.S. breeders would have continued and uninterrupted access to this valuable germplasm.

The OSU Wheat Program will continue to support the increase and distribution of these important nurseries, as financially possible, to insure U.S. breeding programs have access to new international germplasm and genetic stocks. We will work with CIMMYT to identify supporting funds for our management of the FAWWON, WWEEYRT, and WDEEYRT in the coming crop year. As these are the sole remaining international nurseries for winter wheat, they are a critical link between U.S. and international wheat improvement programs to facilitate free exchange of germplasm and information.

5. The last two graduate students supported under the OSU-USAID program were unable to complete their research and thesis prior to the contract closure date. Cesar Lopez, a Ph.D. student, and Marina Costa, an M.S. student, will complete their degree programs in December, 2000. As such, we have used in-house project funds to support their program extensions from July 1 through December 30.

6. Although the USAID-OSU international program is officially closed, we have made efforts to continue international involvement of the OSU wheat research program. Contacts established and renewed at the 6th International Wheat Conference were very important in this regard. At the meeting, Dr. Peterson was asked to serve on the Coordinating Committee for the WWEEYRT nursery program. This fall we have provided germplasm stocks to programs in the Ukraine, Georgia, Hungary, Romania, France, and England, in addition to providing lines to CIMMYT-Turkey as candidates for entry in the upcoming FAWWON and WWEEYRT nurseries. We anticipate that these exchanges of germplasm and information, both formal and informal, will continue well into the future.

7. Over the two last years we have worked, in a supporting role, with CIMMYT and Washington State University to develop a major research proposal for funding collaborative wheat improvement efforts in the Central Asian Caucus region. In the short term we are continuing to investigate opportunities for financial support of the international nursery distributions. Regardless of the outcome of these funding proposals, the OSU wheat program intends to maintain close ties and continue research collaborations with the CIMMYT wheat program. We will remain actively involved in international wheat improvement efforts, as possible, and will continue to collaborate and freely exchange germplasm with our many close friends and colleagues throughout the world.

Publications and Talks

Technical Papers:

Camacho-Casas, M.A., W.E. Kronstad, and A.L. Scharen. 1995. Septoria tritici Resistance and Associations in a Wheat Cross. Crop Sci. July-August 35:971-976.

Saulescu, N.N., and W.E. Kronstad. 1995. Detection of Genotypic Differences in Early Growth Response to Water Stress in Wheat Using the Snow and Tingey System. Crop Sci. May-June 35:928-931.

Saulescu, N.N., and W.E. Kronstad. 1995. Growth Simulation Outputs for Detection of Differential Cultivar Response to Environmental Factors. Crop Sci. May-June 35:773-778.

Moustafa, M.A., L. Boersma, and W.E. Kronstad. 1996. Response of Four Spring Wheat Cultivars to Drought Stress. Crop Sci. July-August 36:982-986.

del Blanco, I. A., S. Rajaram, and W.E. Kronstad. 1999. Agronomic potential of synthetic hexaploid wheat-derived populations. Tech Paper No. 11547 of the Agric. Exp. Stn., OSU. Crop Sci J. In Press

del Blanco, I.A., W.E. Kronstad. 2000. Physiological performance of synthetic hexaploid wheat derived populations. Tech Paper No. 11560 of the Agric. Exp. Stn. OSU. Crop Sci. J. In Press

Lopez, C. G. 2000. Using mixing ability analysis from two-way cultivar mixtures to predict the performance of cultivars in complex mixtures. Field Crops Research. In Press.

Symposia and invitational papers presented:

Baltic States Cereal Breeders and Producers Symposium. Seven scientists from the U.S. and participants from Latvia, Lithuania, and Estonia. June 11-21, 1995. Riga, Latvia. "Conventional and New Approaches to Cereal Breeding", "Enhancing Grain Yields", "End Product Use, Malting Quality", "Technology Transfer", and "International Germplasm Exchange".

CIMMYT/INIA International Workshop. October 22-27, 1995 Montevideo, Uruguay. Presented paper "Current and Potential Barriers to the Free Exchange of Germplasm".

Armenian Technology Group Winter Wheat Program Review. February 3-22, 1996, Yerevan, Armenia.

30th Annual International Workshop. March 27-31, 1996.CIANO, Cd. Obregon, Sonora, MEXICO. Increasing Yield Potential in Wheat: Breaking the Barriers. Presented paper "Genetic Diversity and the Free Exchange of Germplasm in Breaking Yield Barriers".

5th International Wheat Conference. June 10-14, 1996 Ankara, Turkey. Symposium Keynote Speaker. "Agricultural Development and Wheat Breeding in the 21st Century".

Pacific Northwest Wheat Commission White Wheat Quality Symposium. June 12, 1997. Governor Hotel, Portland, Oregon. Invited Speaker, "What Can Science Do to Meet Quality Needs?"

Ukrainian program review. January 29-February 6, 1997.

National Association of Wheat Grower's Summer Leadership Conference Wheat Industry Research Initiative Symposium, "Linking Science to Markets for the 21st Century." June 30, 1997. Portland, Oregon. Invited Speaker, "Wheat Disease Research: Are We Making Progress?"

1997 Western Region Teaching Symposium, The Learning Environment in the New Century. September 19, 1997. Newport, Oregon. Keynote Speaker, "Challenges of Agriculture in the Next Century."

Warren E. Kronstad Honorary Retirement Symposium. February 18, 1999. La Sells Stewart Center, Oregon State University, Corvallis, Oregon. "Impact of Technology on Partner Countries – The Turkish Experience."

Warren E. Kronstad Retirement Appreciation Luncheon. February 19, 1999. The Dalles, Oregon. Oregon State University, Oregon Wheat Commission, Oregon Wheat Grower's League. Career Historical Perspective.

Peterson, C. J. Building on a tradition of excellence. Oregon Wheat. April, 1999.

Other Publications:

W.E. Kronstad. 1998. Agricultural development and wheat breeding in the 20th century. p. 1-10. *In* H.-J. Braun, F. Altay, W.E. Kronstad, S.P.S. Beniwal and A. McNab (Eds.) Wheat: Prospects for global improvement – Developments in Plant Breeding. Kluwer Academic.

Peterson, C.J., D.R. Shelton, T.J. Martin, R.G. Sears, E. Williams, and R.A. Graybosch. 2000. Grain color stability and classification of hard white wheat in the US. In Proceedings of the International Wheat Conference, Budapest, Hungary, June, 2000. In press.

Peterson, C. J., R.E. Allan, C.J. Peterson, Jr., and W.J. Angus. The Pacific Northwest Region. In: The World Wheat Book. Limagrain Agro-Industries, France. In Press.

Nursery Reports

Larson, Mark J. A. and Warren E. Kronstad. 1998. Results of the 20th International Early Maturing Winter x Spring Wheat Screening Nursery (1998-1999). Agricultural Experiment Station Special Report #995 Volume 20(1).

Larson, Mark J. A. and Warren E. Kronstad. 1998. Results of the 20th International Late Maturing Winter x Spring Wheat Screening Nursery (1998-1999). Agricultural Experiment Station Special Report #996 Volume 20(2).

Larson, Mark J. A. and Warren E. Kronstad. 1997. Results of the 19th International Early Maturing Winter x Spring Wheat Screening Nursery (1997-1998). Agricultural Experiment Station Special Report #984 Volume 19(1). 126p.

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